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NATIONAL DAM INSPECTION PROGRAM. MAHANOY TOWNSHIP DAM NUMBER 2.--ETC(U)
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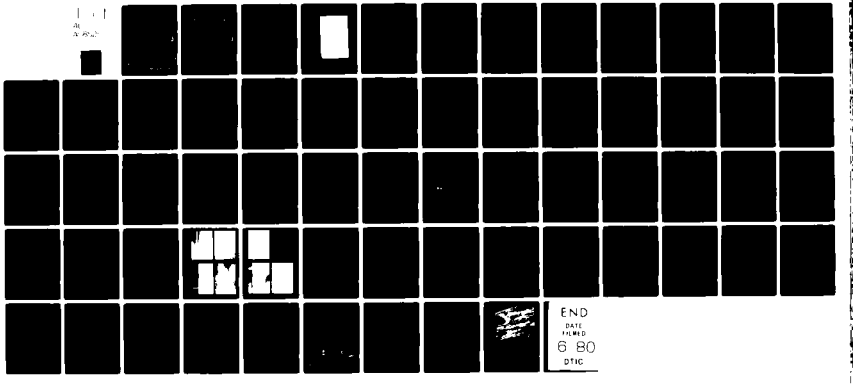

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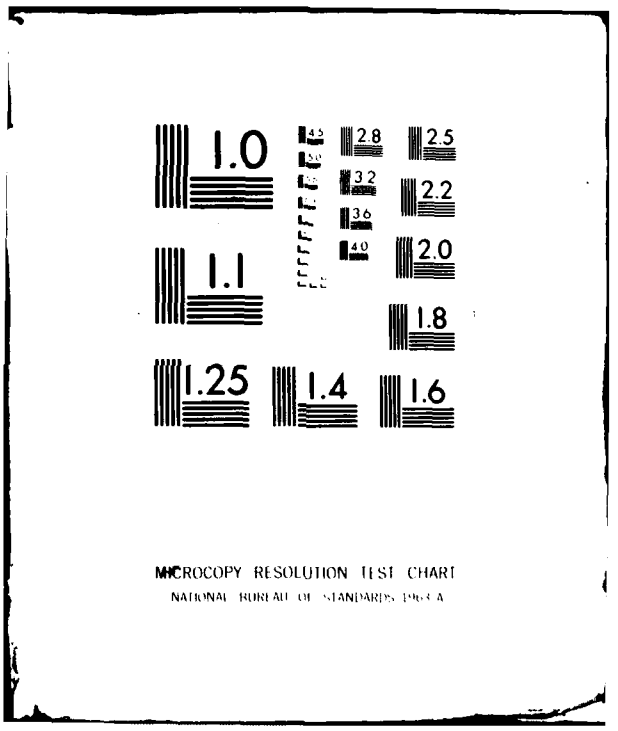
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SUSQUEHANNA RIVER BASIN

COLD RUN, SCHUYLKILL COUNTY

PENNSYLVANIA

LEVEL II

AD A085212

MAHANOY TOWNSHIP DAM NO. 2

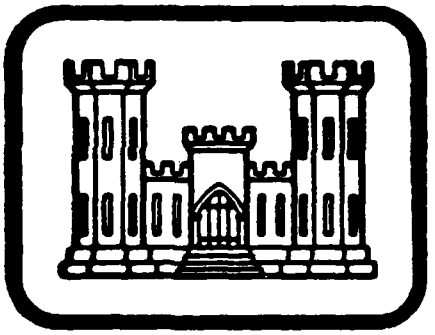
NDS ID NO. PA-685

DER ID NO. 54-34

MAHANOY TOWNSHIP MUNICIPAL AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



Prepared By

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG, PENNSYLVANIA
15931

FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

APRIL, 1980

(L. ROBERT) KIMBALL & ASSOCIATES
Ebensburg, PA

DACW31-80-C-0020

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SUSQUEHANNA RIVER BASIN,
COLD RUN, SCHUYLKILL COUNTY,
PENNSYLVANIA.

(6) NATIONAL DAM INSPECTION PROGRAM.

MAHANOY TOWNSHIP DAM NO. 2.

(NDS ID NUMBER PA-685,
DER ID NUMBER 54-34)

MAHANOY TOWNSHIP MUNICIPAL AUTHORITY.

PHASE I INSPECTION REPORT.

~~NATIONAL DAM INSPECTION PROGRAM~~

(15) DACW31-80-C-0020

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(12) 62

FOR
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

(11) APR 80

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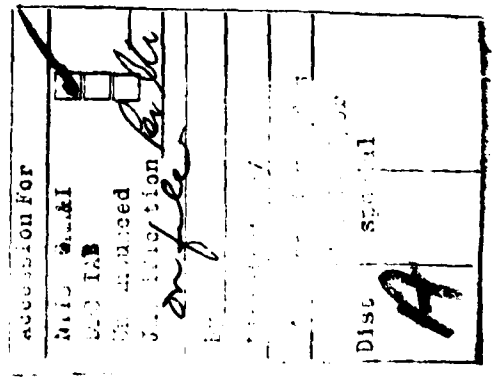
PREFACE

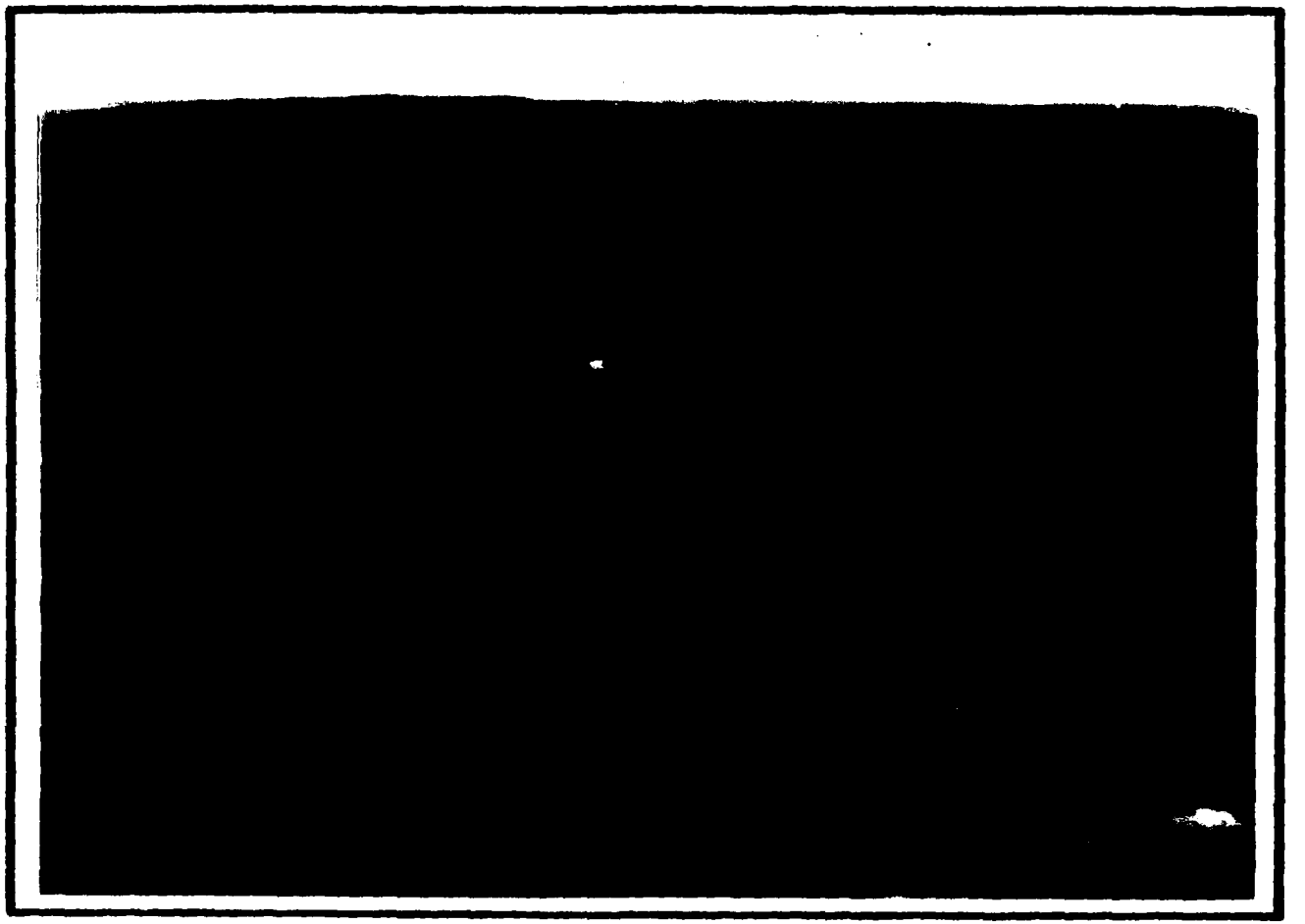
This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in detemining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.





Overview of Mahanoy Township Dam No. 2.

PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM	Mahanoy Township Dam No. 2
STATE LOCATED	Pennsylvania
COUNTY LOCATED	Schuylkill
STREAM	Cold Run
DATE OF INSPECTION	November 8 and 16, 1979

ASSESSMENT

The assessment of Mahanoy Township Dam No. 2 is based upon visual observations made at the time of inspection, review of available records and data, hydraulic and hydrologic computations and past operational performance.

Mahanoy Township Dam No. 2 is a high hazard-small size dam. The spillway design flood (SDF) for this dam is the 1/2 PMF to PMF. Based on the downstream potential for loss of life the SDF is the PMF. The spillway and reservoir are capable of controlling approximately 73% of the PMF without overtopping the embankment. Based on criteria established by the Corps of Engineers, the spillway is termed inadequate. No seepage or wet areas were observed during the inspection on the abutments, slopes nor along the toe of dam.

The following recommendations and remedial measures should be instituted immediately.

1. An additional study should be made, and appropriate measures taken, to provide assurances that flow over the access road at the left abutment will be passed safely beyond the toe of dam. Without such assurances the dam could be considered unsafe.

2. Valves controlling the drainlines should be repaired if necessary. They should be operated and lubricated on a regular basis.

3. Some means of positive upstream closure of the drainlines should be developed in case of emergencies.

4. Possible abandonment of the two foot by three foot masonry conduit should be considered.

5. Riprap should be placed at the discharge point of the 33-inch steel riveted pipe to provide erosion control on the downstream slope of the embankment and at the toe of the dam.

6. A warning system should be developed to warn downstream residents of large spillway discharges or imminent failure of the dam.

7. Regular safety inspections should be conducted in accordance with provisions stipulated by the Commonwealth of Pennsylvania regarding the inspection of dams.

MAHANOY TOWNSHIP DAM NO. 2
PA 685

SUBMITTED BY:

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS

April 24, 1980
Date

R. Jeffrey Kimball
R. Jeffrey Kimball, P.E.

APPROVED BY:

16 May 1980
Date

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

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APPENDICES

PHASE I
NATIONAL DAM INSPECTION PROGRAM
MAHANOY TOWNSHIP DAM NO. 2
NDI. I.D. NO. PA 685
DER I.D. NO. 54-34

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Mahanoy Township Dam No. 2 is an earthfill dam, 1200 feet long and 34 feet high. The top width of the dam is 15 feet. The upstream slope is 2H:1V and protected with riprap. The downstream slope is 1.5H:1V and grass covered.

A valve house is located 400 feet from the right abutment near the downstream toe of the dam. This valve house controls the reservoir drain and distribution system. Entrance to the valve house is provided through a door on the downstream face of the structure. In the valve house there is a 16 inch pipe which reduces to 14 inches in diameter and branches into two 14 inch pipes, one of which serves as a blow-off and the other as a supply line. There is an additional blow-off pipe, 14 inches in diameter, which is operated by a standard gate valve in the reservoir. The valve is equipped with a long stem extending upstream to the top of the embankment. This pipe passes through the embankment and discharges into a 2 foot by 3 foot masonry conduit beneath the dam. The masonry conduit was observed during the inspection but no regulating devices were visible.

Two spillways are located near the left abutment and consist of one 24 inch RCP and one 33 inch steel riveted pipe. The 24 inch reinforced concrete pipe maintains the normal pool elevation. The 33 inch cast iron pipe is located approximately 280 feet from the left abutment and acts as an auxiliary spillway.

b. Location. The dam is located on Cold Run, approximately 1.5 miles north of Mahanoy City, Schuylkill County, Pennsylvania. Mahanoy Township Dam No. 2 can be located on the Shenandoah, U.S.G.S. 7.5 minute quadrangle.

c. Size Classification. Mahanoy Township Dam No. 2 is a small size structure (34 feet high, 102 acre-feet).

d. Hazard Classification. Mahanoy Township Dam is a high hazard dam. Downstream conditions indicate that loss of more than a few lives is probable should the structure fail. The village of Craigs is located approximately 0.4 miles downstream of the dam.

e. Ownership. Mahanoy Township Dam No. 2 is owned by Mahanoy Township Authority. Correspondence should be addressed to:

Mahanoy Township Authority
46 Main Street
Mahanoy City, PA 17948
Attention: George Palmer, Manager
(717)773-0650

f. Purpose of Dam. Mahanoy Township Dam No. 2 is used for water storage.

g. Design and Construction History. No information is available on the design or construction history. It is believed the dam was constructed around 1884. The embankment suffered a partial failure and was repaired in 1892 (see page B-3).

h. Normal Operating Procedures. Mahanoy Township Dam No. 2 is supplied through two 20 inch pipes from Reservoir No. 1, which are equipped with automatic valves which during high reservoir stages, diverts flow into Reservoir No. 3. Excess inflow is discharged through two overflow pipes, one 24 inch RCP and one 33 inch steel riveted pipe. The owner stated that no operations are conducted at the dam.

1.3 Pertinent Data.

a. Drainage Area. 0.30 square miles

b. Discharge at Dam Site (cfs).

Maximum known flood at dam site	Unknown
Drainline capacity at normal pool	Unknown
Spillway capacity at top of dam (24" RCP & 33" steel riveted pipe)	90
Additional spillway capacity (left abutment)	582

c. Elevation (U.S.G.S. Datum) (feet). - Field survey based on pool elevation 1685 shown on U.S.G.S. 7.5 minute quadrangle.

Top of dam - low spots (main embankment)	1689.6
Top of dam - design height	Unknown
Low spot (left abutment)	1687.9

Normal pool	1685.0
Culvert spillway upstream invert (24" CIP)	1684.5
Culvert spillway downstream invert (24" CIP)	1684.1
Auxiliary spillway upstream invert (33" SRP)	1685.2
Auxiliary spillway downstream invert (33" SRP)	1684.6
Streambed at centerline of dam	1655.6
Maximum tailwater	None.
Toe of dam	1655.6

d. Reservoir (feet).

Length of maximum pool (PMF)	750
Length of normal pool	700

e. Storage (acre-feet).

Normal pool	64
Top of dam	102

f. Reservoir Surface (acres).

Top of dam	9.5
Normal pool	6.9
Spillway crest	6.9

g. Dam.

Type	Earthfill
Length	1200'
Height	34'
Top width	15'
Side slopes - upstream	2H:1V
- downstream	1.5H:1V
Zoning	Unknown
Impervious core	Unknown
Cutoff	Unknown
Grout curtain	Unknown

h. Reservoir Drain.

Type	Two 14" CIP's
Length	Approximately 110'
Closure	Stem on upstream slope and valve house
Access	Valve house
Regulating facilities	Valve house

1. Spillway.

Type	24" RCP, 33" steel riveted pipe
Length	N/A
Crest elevation	1685.0
Upstream channel	Unrestricted
Downstream channel	Open channel to Reservoir No. 3 and Cold Run

SECTION 2
ENGINEERING DATA

2.1 Design. Review of information in the files of the Commonwealth of Pennsylvania, Department of Environmental Resources reveals that several inspection reports, some correspondence and photographs were available for review. No design data, construction drawings or history of the dam were contained in the files. The owner had no data on the dam. The DER files were reviewed for this study.

2.2 Construction. No information is available on construction of the dam.

2.3 Operation. No operating records are maintained.

2.4 Evaluation.

a. Availability. Engineering data were provided by PennDER, Bureau of Dams and Waterways Management. The owner stated that no operation or maintenance had been conducted at the dam. The owner did not accompany the inspection team during the inspection.

b. Adequacy. There is no design data or other information available. The Phase I report is based on the visual inspection and hydraulic and hydrologic analyses.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The onsite inspection of Mahanoy Township Dam No. 2 was conducted by personnel of L. Robert Kimball and Associates on November 8 and 16, 1979. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway faciliities, exposed portion of any outlet works and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

b. Dam. The dam appears to be in fair condition. From a brief survey conducted during the inspection, it was noted that the crest of the dam rises toward the right abutment. The low spots on the main embankment occur at approximately Station 6+00 and at the right abutment. A second low spot was noted at the left abutment and could provide additional spillway capacity since the area is in natural ground. The upstream slope was measured to be 2H:1V and covered with riprap. The crest width was measured to be 15 feet. The downstream slope was grass covered and was measured to be 1.5H:1V. No seepage or erosion areas were noted during the inspection.

c. Appurtenant Structures. The reservoir level at the time of inspection was approximately 1685.0. The culvert spillway appeared to be in fair condition. The culvert spillway consists of a 24 inch reinforced concrete pipe which outlets into an open channel which eventually flows into Reservoir No. 3. A second pipe which acts as an auxiliary spillway is located at Station 2+80 and is a 33 inch steel riveted pipe. No erosion protection is provided on the downstream slope from discharges through the 33" pipe. Neither pipe was protected against upstream blockage (no trash racks). The culvert spillway is located near the left abutment and runs under a roadway which provides access to Dam No. 1.

One of two reservoir drains is controlled in the valve house which is located near the toe of the dam at Station 8+00. Access to this valve house is through a doorway on the downstream face of the structure. A second drain which is located in a two by three foot masonry conduit is controlled by a valve stem located on the upstream slope of the embankment at Station 7+28. At the time of inspection there was no discharge noted at the outlet of the two by three foot masonry conduit or through the 14" pipe which is controlled in the valve house near the toe of dam.

d. Reservoir Area. The watershed is covered mostly with woodland. The reservoir slopes are gentle and do not appear to be susceptible to massive landslides which would affect the storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. The downstream channel of Cold Run is relatively narrow for approximately 1 mile before it flows into North Mahanoy Creek. North Mahanoy Creek is also relatively narrow and eventually flows through Mahanoy City. Approximately ten (10) homes and forty (40) people are located 0.5 miles downstream of the Mahanoy Township Dam No. 2.

3.2 Evaluation. The embankment and spillway appears to be in fair condition. The outlet works appear to be in poor condition, and the appurtenant structures are not operated or maintained.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. Water is drawn off the reservoir through the outlet works and eventually becomes part of the water system of Mahanoy City. According to the owner the outlet works are not operated. The reservoir is maintained at a normal pool elevation of 1685.0. The excess inflow discharges through a culvert spillway into an open channel which flows into Reservoir No. 3. The reservoir drain is not operated.

4.2 Maintenance of the Dam. No planned maintenance schedule exists. Maintenance of the dam is non-existent according to the owner. Maintenance of the dam is considered poor.

4.3 Maintenance of Operating Facilities. The operating facilities are not maintained. Maintenance of these operating facilities is considered poor.

4.4 Warning System in Effect. There is no warning system in effect to warn downstream residents of large spillway discharges or imminent failure of the dam.

4.5 Evaluation. Maintenance of the dam and operating facilities is considered poor. There is no warning system in effect to warn downstream residents.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. No calculations or design data pertaining to hydrology were available.

b. Experience Data. No rainfall, runoff or reservoir level data were available. The spillway reportedly has functioned adequately in the past.

c. Visual Observations. The principal spillway (24" culvert spillway) appeared to be in fair condition. A second pipe (33" steel riveted pipe) which would act to discharge water during periods of high inflow discharge on the embankment slope near the left abutment. The flow enters an open channel which runs parallel to the toe between the toe and a roadway which provides access to the reservoirs. This discharge would eventually join Cold Run at the village of Craigs approximately 1/2 mile downstream.

A low spot in the natural ground near the left abutment would also serve to provide additional spillway capacity since discharges in this area would follow the access road to the reservoirs and eventually join Cold Run.

A low spot was noted on the main embankment at approximately Station 6+00. This area is distinguished from the low spot located near the left abutment since it occurs on the main embankment in an area susceptible to erosion due to overtopping, and critical in regards to embankment stability.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, July, 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D.

5.2 Evaluation Assumptions. To enable us to complete the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions.

1. A pool elevation of 1685.0 was assumed prior to the storm.

2. The low spot on the embankment (elevation 1689.6) was considered the top of dam.

2. The low spot area at the left abutment was considered as providing additional spillway capacity. This additional spillway capacity will be evaluated by the use of the $L, $V option provided in the HEC-1 program.

5.3 Summary of Overtopping Analysis. Complete summary sheets for the computer output are presented in Appendix D.

Peak inflow (PMF)	918 cfs
Spillway capacity (24 inch RCP, 33 inch CIP)	90 cfs
Additional capacity (left abutment)	582 cfs

a. Spillway Adequacy Rating. The Spillway Design Flood (SDF) for this dam is 1/2 PMF to PMF. The SDF based on the downstream potential for loss of life is considered as the PMF. Based on the following definition provided by the Corps of Engineers, the spillway is rated as inadequate as a result of our hydrologic analysis.

> Inadequate - For all high hazard dams which do not safely pass the SDF (PMF).

The spillway and reservoir are capable of controlling approximately 73% of the PMF without overtopping the dam (based on low spot elevation on the main embankment). This spillway capacity assumes flow over the low area near the left abutment. This low area should be evaluated by a professional engineer knowledgeable in dam design and analysis to determine if flow through this area will cause erosion and affect the stability of the structure and if necessary additional erosion protection should be provided immediately.

5.4 Summary of Dam Breach Analysis. As the subject dam can satisfactorily pass 50% of the PMF (based on our analyses) it was not necessary to perform a breach analysis and downstream routing of the flood wave.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. No signs of slumping or major erosion were noted during the inspection. No signs of seepage were noted on the downstream slope or at the toe.

The existence of the 33 inch steel riveted pipe through the main embankment near the left abutment which discharges into an open channel between the toe of the dam and a roadway could be a cause for potential erosion and eventual instability of the structure.

b. Design and Construction Data. No design or construction data is available. No stability analyses have been conducted for this dam.

c. Operating Records. No operating records are maintained.

d. Post Construction Changes. No post construction changes are known to have occured.

e. Seismic Stability. The dam is located in seismic zone 1. No seismic stability analysis has been performed. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The dam appears to be in fair condition but poorly maintained. The outlet works and reservoir drains are not operated. The existence of the 33 inch steel rivet pipe through the main embankment which discharges at the toe of the dam provides the potential for possible future instability of the structure. The visual observations, review of available data, hydrologic and hydraulic calculations and operational performance indicate that the spillway at Mahanoy Dam No.2 is inadequate. The spillway is capable of controlling approximately 73% of the PMF without overtopping the embankment.

b. Adequacy of Information. Sufficient information is available to complete a Phase I report.

c. Urgency. The recommendations suggested below should be implemented as soon as possible.

d. Necessity for Further Investigation. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required.

7.2 Recommendations/Remedial Measures.

1. An additional study should be made, and appropriate measures taken, to provide assurances that flow over the access road at the left abutment will be passed safely beyond the toe of dam. Without such assurances the dam could be considered unsafe.

2. Valves controlling the drainlines should be repaired if necessary. They should be operated and lubricated on a regular basis.

3. Some means of positive upstream closure of the drainlines should be developed in case of emergencies.

4. Possible abandonment of the two foot by three foot masonry conduit should be considered.

5. Riprap should be placed at the discharge point of the 33 inch steel riveted pipe to provide erosion control on the downstream slope of the embankment and at the toe of the dam.

6. A warning system should be developed to warn downstream residents of large spillway discharges or imminent failure of the dam.

7. Regular safety inspections should be conducted in accordance with provisions stipulated by the Commonwealth of Pennsylvania regarding the inspection of dams.

APPENDIX A
CHECKLIST, VISUAL INSPECTION, PHASE I

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Mahanoy Township Dam No 2 COUNTY Schuylkill STATE Pennsylvania ID# PA 54-34

TYPE OF DAM Earthfill HAZARD CATEGORY

DATE(s) INSPECTION November 8 & 16, 1979 WEATHER Cloudy, cold TEMPERATURE mid 30°

POOL ELEVATION AT TIME OF INSPECTION 1685.0 M.S.L. TAILWATER AT TIME OF INSPECTION N/A M.S.L.

A-1

INSPECTION PERSONNEL:

R. Jeffrey Kimball - L. Robert Kimball and Associates

James T. Hockensmith - L. Robert Kimball and Associates

O.T. McConnell - L. Robert Kimball and Associates

James T. Hockensmith RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None noted.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None noted.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Low spot noted near mid embankment. Crest rises toward right abutment. Mahanoy Dam is semi-circular in shape.	
RIPRAP FAILURES	None.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Negligable.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appears to be good.	
ANY NOTICEABLE SEEPAGE	None noted.	
STAFF GAUGE AND RECORDER	None.	
DRAINS	Two 14 inch diameter pipes, one pipe discharges into a two foot by three foot masonry conduit beneath the dam.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None noted.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None noted.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Low spot noted near mid embankment. Crest rises toward right abutment. Mahanoy Dam is semi-circular in shape.	
RIPRAP FAILURES	None.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Not applicable.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not applicable.	
DRAINS	Not applicable.	
WATER PASSAGES	Not applicable.	
FOUNDATION	Not applicable.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not applicable.	
STRUCTURAL CRACKING	Not applicable.	
VERTICAL AND HORIZONTAL ALIGNMENT	Not applicalbe.	
MONOLITH JOINTS	Not applicable.	
CONSTRUCTION JOINTS	Not applicable.	
STAFF GAUGE OR RECORDER	Not applicable.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not applicable.	
INTAKE STRUCTURE	One 16 inch pipe reduces to 14 inch diameter and branches into two 14 inch pipes at valve house.	
OUTLET STRUCTURE	None.	
OUTLET CHANNEL	Cold Run and open channel to Reservoir No. 1.	
EMERGENCY GATE	Valve in valve house and a standard gate valve in reservoir.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	None.	
APPROACH CHANNEL	Lake.	
DISCHARGE CHANNEL	Open cut channel to Reservoir No. 3 and Cold Run.	
BRIDGE AND PIERS	Not applicable.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable.	
APPROACH CHANNEL	Not applicable.	
DISCHARGE CHANNEL	Not applicable.	
BRIDGE AND PIERS	Not applicable.	
GATES AND OPERATION EQUIPMENT	Not applicable.	

DOWNSTREAM CHANNEL

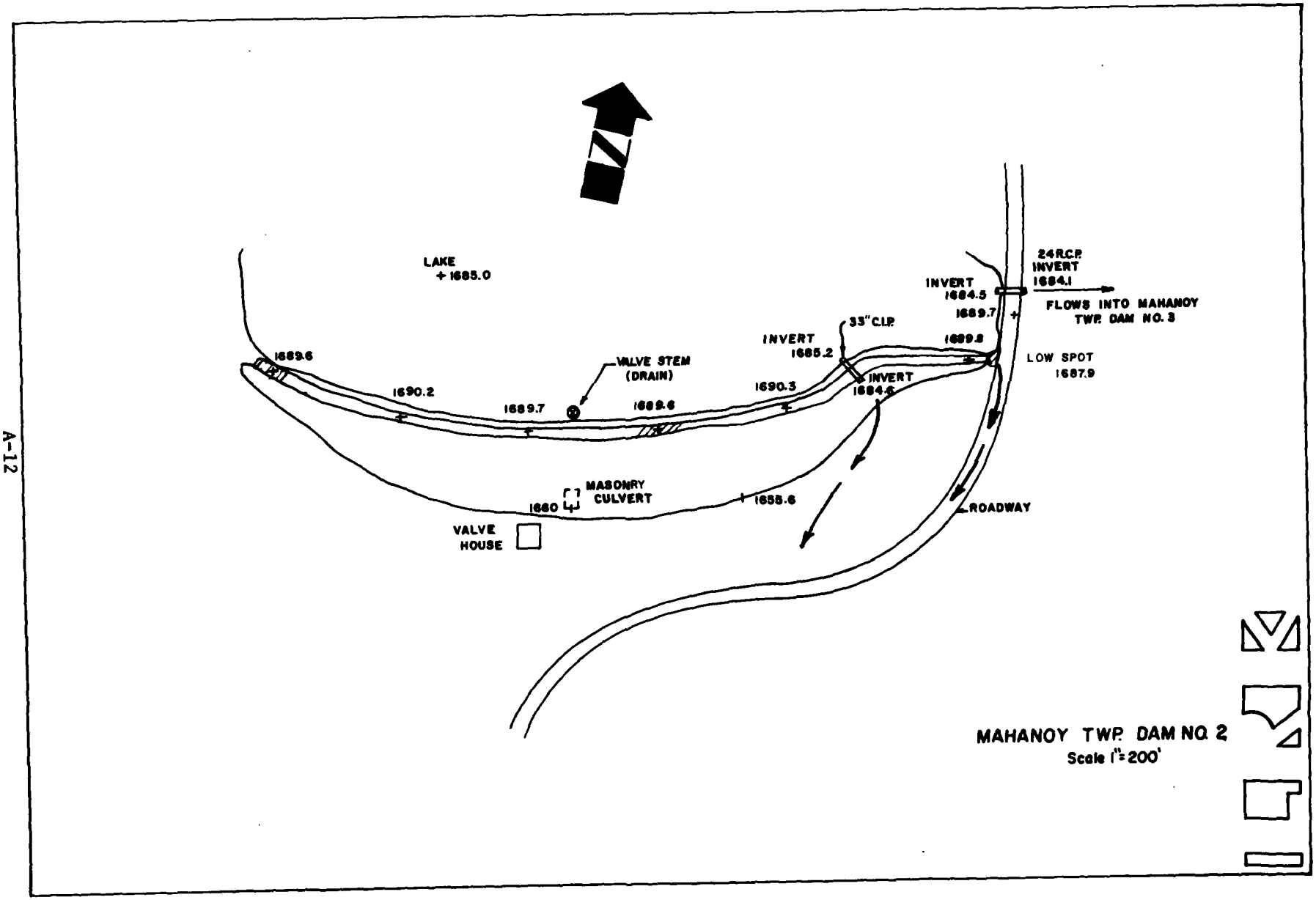
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Narrow channel for approximately 1 mile before entering North Mahanoy Creek.	
SLOPES	Appear to be stable.	
APPROXIMATE NO. OF HOMES AND POPULATION	Approximately 10 homes - 40 people within 0.5 miles of dam. Homes located in the village of Craigs on Cold Run.	

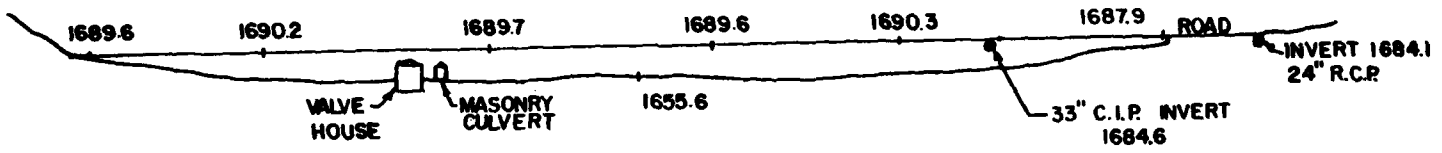
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderately steep. Appear to be stable.	
SEDIMENTATION	Does not appear to be excessive.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	


LAKE
+ 1685.0
1689.6
1690.2
1689.7
VALVE STEM
(DRAIN)
1689.6
1690.3
INVERT
1685.2
33" C.I.P.
INVERT
1684.6
1689.8
INVERT
1684.5
1689.7
24 R.C.P.
INVERT
1684.1
FLOWS INTO MAHANOY
TWP. DAM NO. 3
LOW SPOT
1687.9
MASONRY
CULVERT
1660
1658.6
VALVE
HOUSE
ROADWAY
MAHANOY TWP. DAM NO. 2
Scale 1"=200'



PROFILE
LOOKING UPSTREAM

MAHANOY TWP. DAM NO. 2
Scale 1"=200'

APPENDIX B
CHECKLIST, ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION, PHASE I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM ~~Mahaney Township~~ Dam No. 2
ID# PA 685

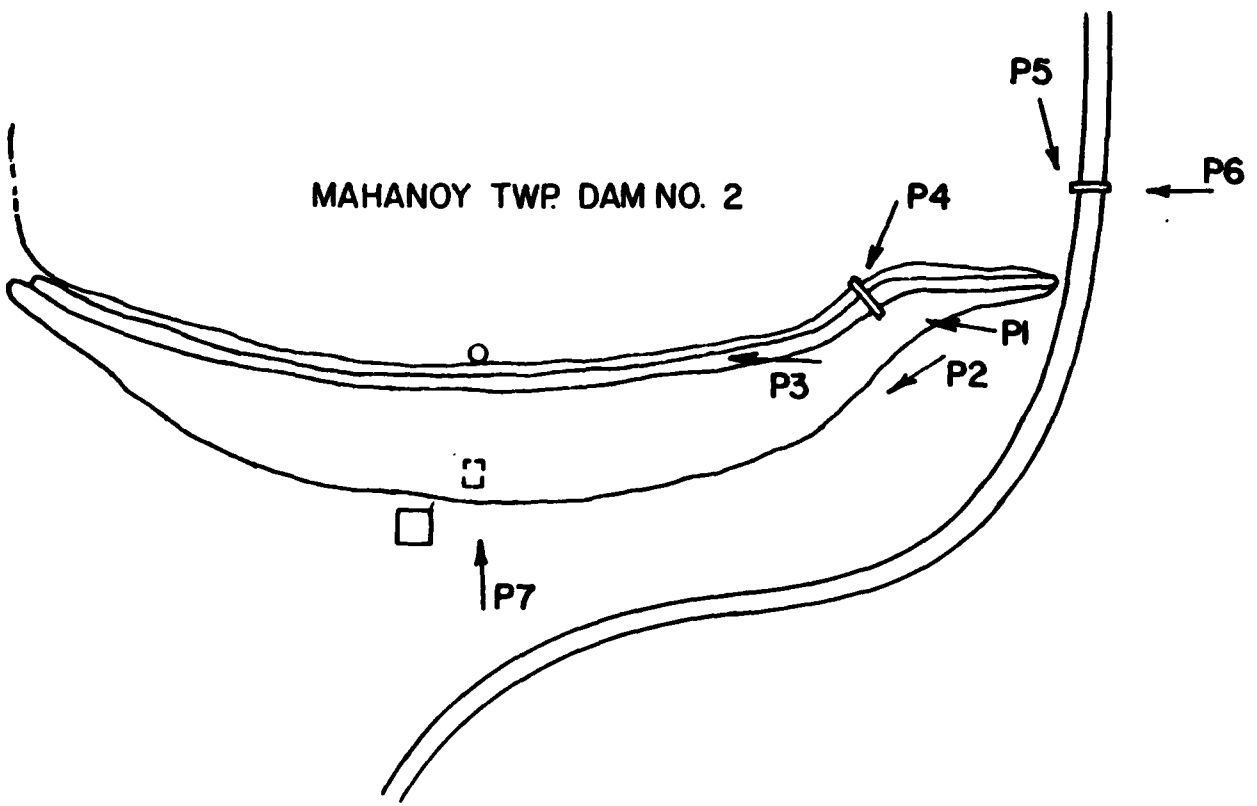
ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. quadrangle.
CONSTRUCTION HISTORY	None.
TYPICAL SECTIONS OF DAM	None.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS RAINFALL/RESERVOIR RECORDS	None. None. None. None. None.

ITEM	REMARKS
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Unknown.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Unknown

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	Unknown
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	The dam suffered a partial failure at 9:00 p.m. June, 17, 1892, resulting in the breach in the embankment 25 to 30 feet east of the centerline. The "Engineering News" in noting the failure does not assign the cause but states that much damage was done and one life lost.
MAINTENANCE OPERATION RECORDS	None.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	None.
OPERATING EQUIPMENT PLANS & DETAILS	None.

APPENDIX C
PHOTOGRAPHS



C-1

P–INDICATES PHOTO LOCATION

MAHANOY TWP. DAM NO. 2
PHOTO INDEX

MAHANOY TOWNSHIP DAM NO. 2

Photograph Descriptions

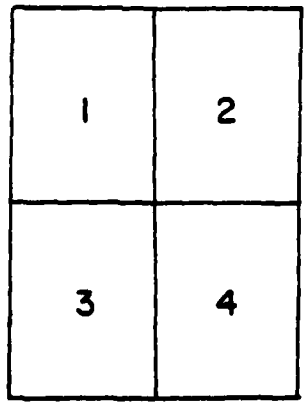
Sheet 1. Front

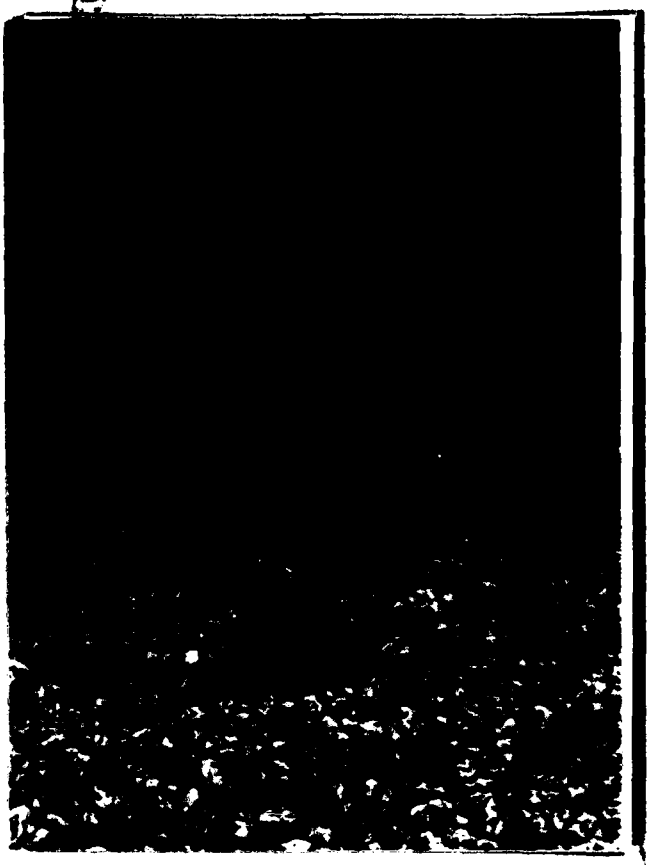
(1) Upper left - Downstream slope of dam and discharge end of auxiliary spillway.
(2) Upper right - Discharge channel for auxiliary spillway.
(3) Lower left - Upstream slope and crest of dam.
(4) Lower right - Entrance to auxiliary spillway.

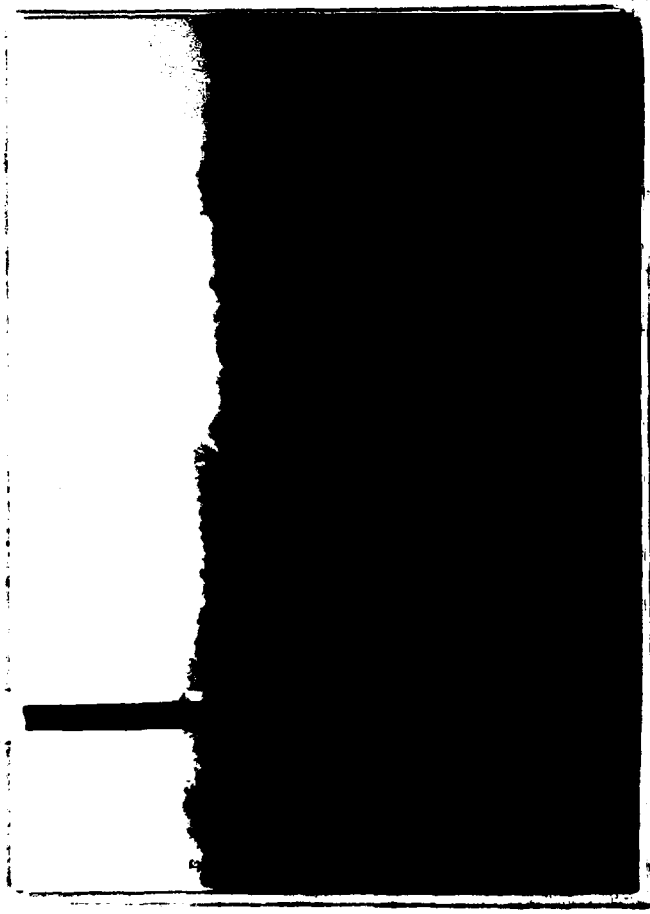
Sheet 1. Back

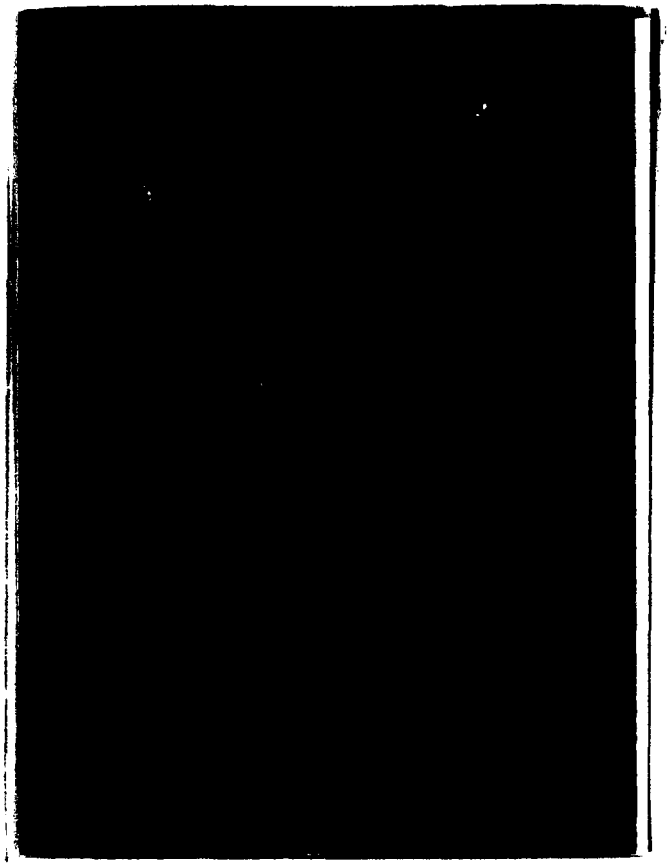
(5) Upper left - Entrance to main spillway.
(6) Lower left - Downstream slope of discharge end of main spillway.
(7) Lower right - masonry conduit discharge for auxiliary blow off.

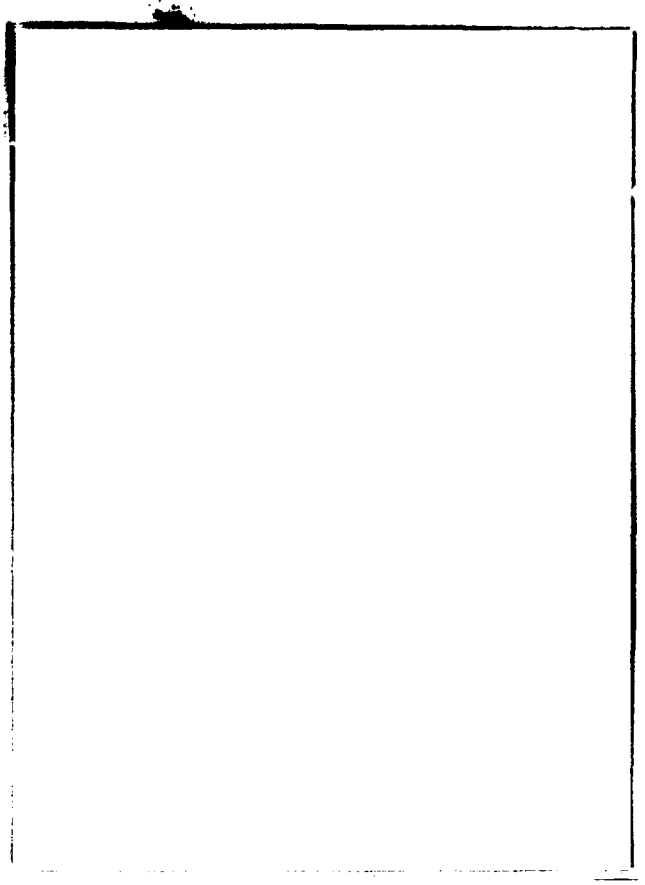
TOP OF PAGE

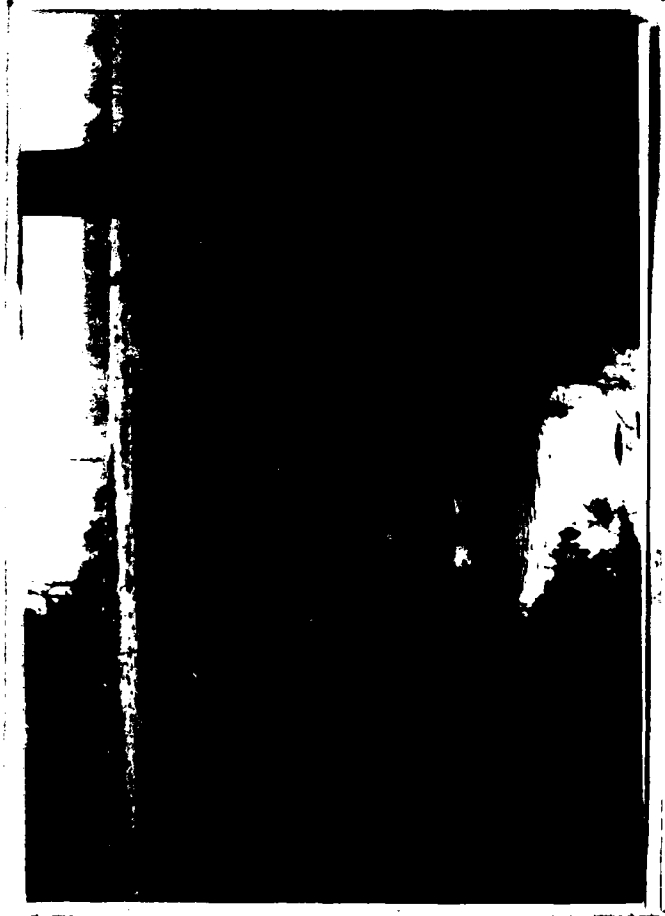


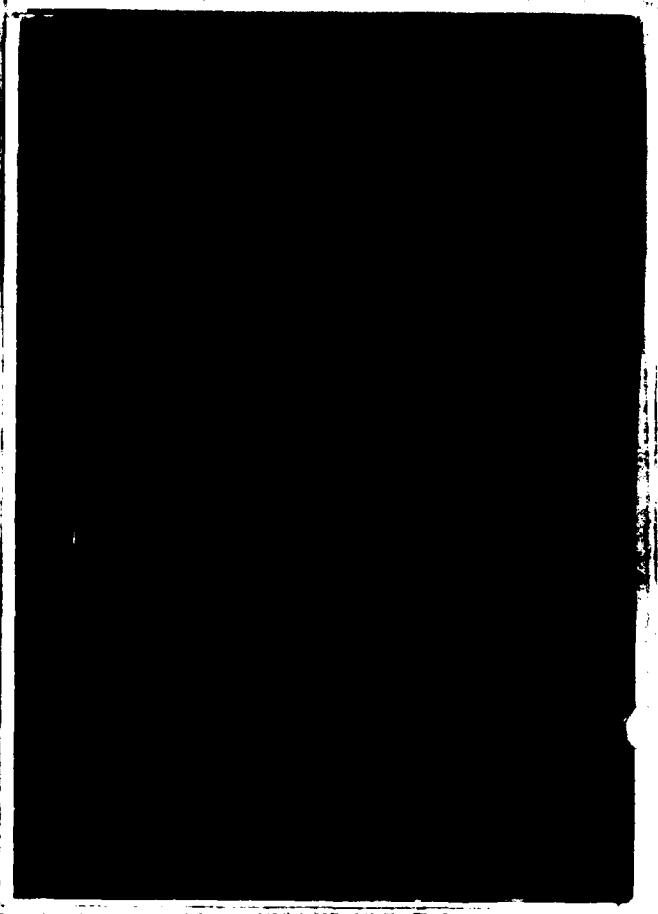












APPENDIX D
HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Investigation), September, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analysis is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Report No. 40" prepared by the U.S. Weather Bureau.

The index rainfall is reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
Ct	Coefficient representing variations of watershed	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topgraphic
Lca	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
Cp	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input or sufficient dimensions input and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF the computer program will calculate the percentage of the PMF which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre-failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.

HYDROLOGY AND HYDRAULICS ANALYSIS
DATA BASE

NAME OF DAM: Mahanoy Township Dam No. 2

PROBABLE MAXIMUM PRECIPITATION (PMP) = 22.2 (1.005) = 22.3 inches

STATION	1	2	3
Station Description	Mahanoy Township Dam No. 2		
Drainage Area (square miles)	0.3		
Cumulative Drainage Area (square miles)	0.3		
Adjustment of PMF for Drainage Area (%)(1)			
6 hours	117		
12 hours	127		
24 hours	136		
48 hours	143		
72 hours			
Snyder Hydrograph Parameters			
Zone (2)	13		
Cp (3)	0.50		
Ct (3)	1.85		
L (miles) (4)	0.76		
Lca (miles) (4)	0.28		
tp = Ct(LxLca) 0.3 hrs.	1.16		
Spillway Data			
Crest Length (ft)	N/A		
Freeboard (ft)	2.9		
Entrance Coefficient	0.8		
Exponent	N/A		

(1) Hydrometeorological Report 40 (Figure 1), U.S. Army Corps of Engineers, 1965.

(2) Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's coefficients (C_p and C_t).

(3) Snyder's Coefficients.

(4) L=Length of longest water course from outlet to basin divide. L_{ca}=Length of water course from outlet to point opposite the centroid of drainage area.

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: DA = 0.3 mi^2 wooded.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 64 ac-ft.

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 102 ac.ft

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1689.6

SPILLWAY CREST:

a. Elevation 1685.0
b. Type 24 inch RCP culvert spillway
c. Width N/A
d. Length N/A
e. Location Spillover Left abutment.
f. Number and Type of Gates None.

OUTLET WORKS:

a. Type 16 inch CIP reduces to 14 CIP
b. Location Maximum section.
c. Entrance inverts Unknown.
d. Exit inverts Approximately 1647.5 feet
e. Emergency draindown facilities One 14 inch CIP, one 2 x 3 masonry conduit

HYDROMETEOROLOGICAL GAUGES:

a. Type None.
b. Location None.
c. Records None.

MAXIMUM NON-DAMAGING DISCHARGE: Unknown.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME MAHANOY TWP. DAM No. 2
I.D. NUMBER PA. 54-34
SHEET NO. 1 OF 2
BY OTM DATE 3-12-80

LOSS RATE AND BASE FLOW PARAMETERS

STRTL = 1 INCH
CNSTL = 0.05 IN./HR
STRTQ = 1.5 cfs/mi.^{2}
QRCSN = 0.05 (5% OF PEAK FLOW)
RTIOR = 2.0

ELEVATION - AREA - CAPACITY RELATIONSHIPS

FROM U.S.G.S. 7.5-MIN. QUAD., DER FILES AND FIELD INSPECTION DATA.

AT SPILLWAY CREST ELEVATION = 1685
INITIAL STORAGE = 64.4 AC.FT
POND SURFACE AREA = 6.9 AC.

AT ELEV. 1690, AREA = 9.6 AC.
" " 1700, " = 18.4 AC

FROM THE CONIC METHOD FOR RESERVOIR VOLUME. FLOOD HYDROGRAPH PACKAGE (HEC-1), DAM SAFETY VERSION (USER'S MANUAL).

$H = 3V/A = 3(64.4)/6.9 = 28'$

ELEVATION WHERE AREA EQUALS ZERO;

$1685' - 28' = 1657'$

AREA (AC.)	0	6.9	9.6	18.4
ELEV (FT.)	1657	1685	1690	1700

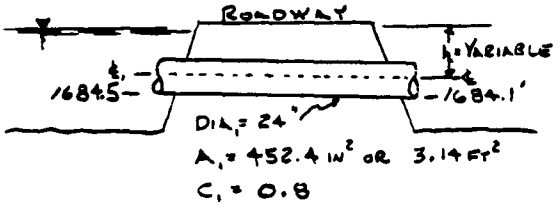
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME MAHANOY TWP. DAM NO. 2
I.D. NUMBER PA 54-34
SHEET NO. 2 OF 2
BY OTM DATE 4-14-80

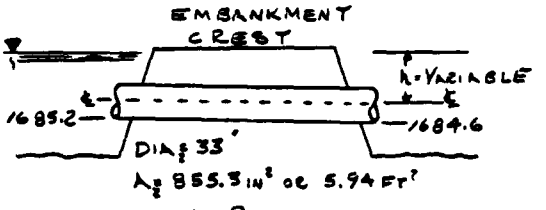
DISCHARGE RATING CURVE

FROM $Q = CA\sqrt{2gh}$ WHERE $C = 0.8$
FROM DESIGN OF SMALL DAMS
1960, FIG. 249, P. 363

24" R.C.P.	33' C.I.P.



$A_1 = 452.4$ IN^2 OR 3.14 FT^2
$C_1 = 0.8$



$A_2 = 855.3$ IN^2 OR 5.94 FT^2
$C_2 = 0.8$

ASSUME FULL FLOW IN PIPES — (ENTRANCE CONTROLS)
A = AREA OF PIPE (FT^2), C = ENTRANCE COEFFICIENT
h = HEAD = UPSTREAM WATER LEVEL - DOWNSTREAM INV. + (DIA./2)

ELEV. (FT.)	24" R.C.P. h(FT)	24" R.C.P. Q (cfs)	33" C.I.P. h(FT)	33" C.I.P. Q (cfs)	*Q (cfs)
1684.5	0	0			0
1687.2	2	29			30
1688	2.8	34	2	29	60
1689	3.8	39	3	35	70
1690	4.8	44	4	40	90
1692	6.8	53	6	49	100
1694	8.8	60	8	57	120
1696	10.8	66	10	64	130
1698	12.8	72	12	70	140
1700	14.8	78	14	75	150

*VALUES ROUNDED TO NEAREST 10 cfs.

NOTE: ADDITIONAL SPILLWAY CAPACITY EXISTS NEAR THE LEFT ABUTMENT. THIS ADDITIONAL CAPACITY WILL BE INVESTIGATED BY USE OF THE $L, $V (HEC-1) PROGRAM OPTION. AREA OF OVERFLOW IS APPROXIMATED FROM PHASE I DATA.

OVERTOP PARAMETERS

TOP OF DAM ELEV. (LOW SPOTS, MAIN EMBANKMENT) = 1689.6'
LOW SPOT ON LT. ABUTMENT = 1687.9'
LENGTH OF DAM = 1200'
COEFFICIENT OF DISCHARGE = 3.0 (BROAD CREST)
$LMAX. = 1500', $YMAX. = 1695'

```
OUTPUT 4,P02,T60,CM330000.
USER,LRK100,LRK100,79012404503NOTM)
GET,HECPF/UN=FKSAPP.
CALL,HECPF,HEC108.
/*EOR
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF MAHANOY TWP. DAM NO. 2
A3       RATIOS OF PMF ROUTED THROUGH THE RESERVOIR  (PA. 54-34)
B     288                10
B1      5
J       1         5        1
J1     .1        .3       .5       .7       1
K       0         1                                    1
K1       INFLOW
M       1         1      0.3
P                22.3     117      127      136      143
I                                                  1.0     0.05
W    1.16     0.50
X    -1.5     -.05     2.0
K       1         2                                    1
K1       ROUTE
Y                                    1        1
Y1      1                                                -1685      -1
Y4 1684.5  1687.2     1688     1689     1690     1692     1694     1696     1698     1700
Y5      0        30       80       70       90      100      120      130      140      150
SA      0       6.9      9.6     18.4
SE   1657     1685     1690     1700
SS   1685
SD 1689.6      3.0      1.5     1200
SL     10       55     1200     1500
SV   1688     1689     1690     1695
K      99
/*EOF
```

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****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

RUN DATE= 80/03/06.
TIME= 13.51.06.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF MAHANOY TWP. DAM NO. 2
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR (PA. 54-34)

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
488	0	10	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1

RTIOS= .10 .30 .50 .70 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.30	0.00	.30	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96.
0.00	22.30	117.00	127.00	136.00	143.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

3/6

UNIT HYDROGRAPH DATA
TP= 1.16 CP= .50 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 7.51 AND R= 9.35 INTERVALS

UNIT HYDROGRAPH 54 END-OF-PERIOD ORDINATES, LAG= 1.17 HOURS, CP= .50 VOL= 1.00

4.	15.	31.	48.	65.	78.	84.	83.	76.	69.
62.	55.	50.	45.	40.	36.	32.	29.	26.	24.
21.	19.	17.	15.	14.	12.	11.	10.	9.	8.
7.	7.	6.	5.	5.	4.	4.	3.	3.	3.
2.	2.	2.	2.	2.	1.	1.	1.	1.	1.
1.	1.	1.	1.						

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	918.	571.	183.	92.	26431.
CMS	26.	16.	5.	3.	748.
INCHES		17.70	22.64	22.77	22.77
MM		449.50	575.08	578.26	578.26
AC-FT		283.	362.	364.	364.
THOUS CU M		349.	447.	449.	449.

4/6

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1685.	-1

STAGE	1684.50	1687.20	1688.00	1689.00	1690.00	1692.00	1694.00	1696.00	1698.00
1700.00									
FLOW	0.00	30.00	60.00	70.00	90.00	100.00	120.00	130.00	140.00
150.00									
SURFACE AREA=	0.	7.	10.	18.					
CAPACITY=	0.	64.	105.	243.					
ELEVATION=	1657.	1685.	1690.	1700.					

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
1685.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
1689.6	3.0	1.5	1200.

CREST LENGTH	10.	55.	1200.	1500.
AT OR BELOW ELEVATION	1688.0	1689.0	1690.0	1695.0

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .30	RATIO 3 .50	RATIO 4 .70	RATIO 5 1.00
HYDROGRAPH AT	1	.30	1	92.	275.	459.	643.	918.
		(.78)		(2.60)	(7.80)	(13.00)	(18.20)	(26.00)
ROUTED TO	2	.30	1	36.	246.	457.	641.	918.
		(.78)		(1.02)	(6.96)	(12.94)	(18.16)	(26.01)

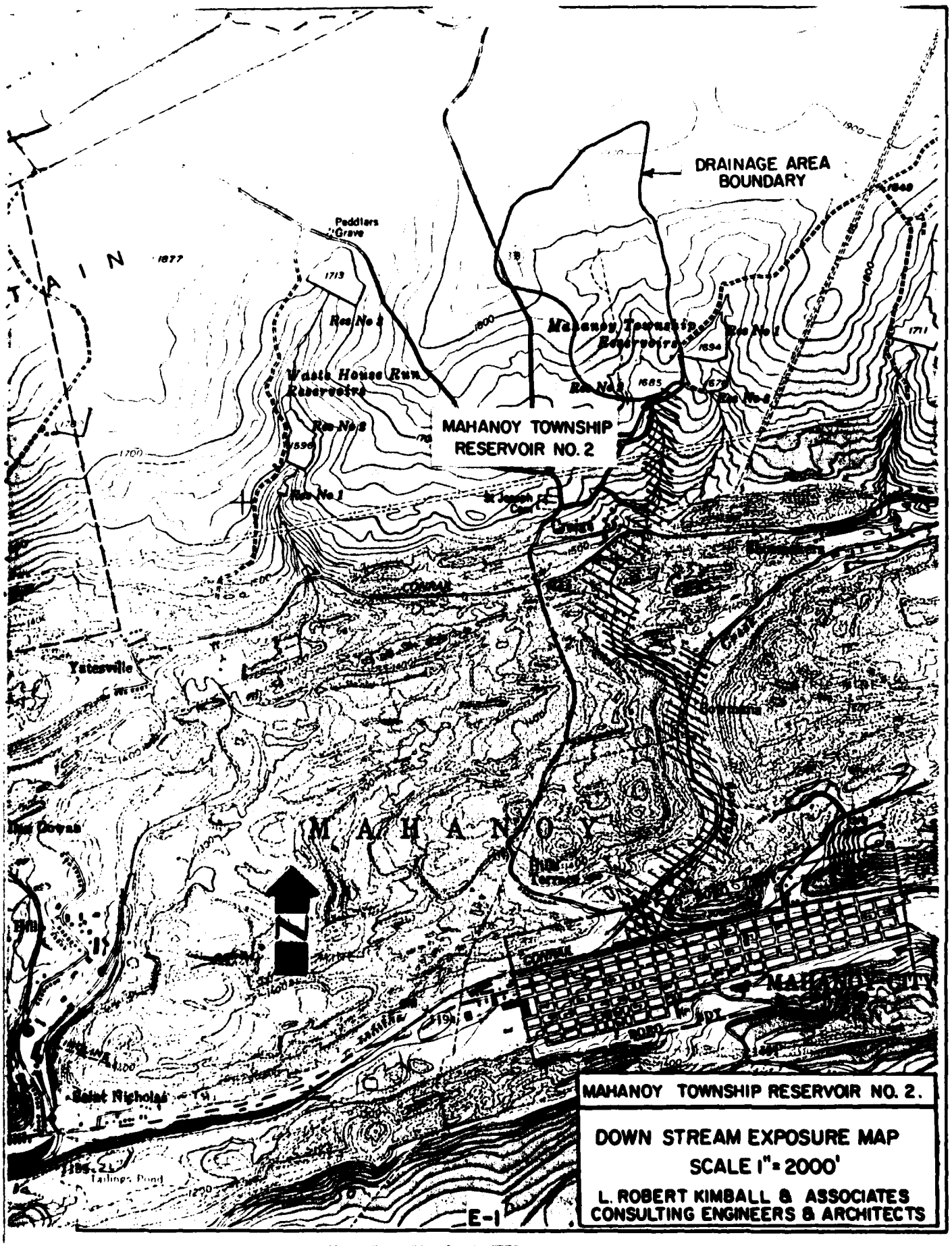
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1685.00	1685.00	1689.60
STORAGE	64.	64.	102.
OUTFLOW	6.	6.	672.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	1687.36	0.00	82.	36.	0.00	43.50	0.00
.30	1689.24	0.00	98.	246.	0.00	41.33	0.00
.50	1689.46	0.00	100.	457.	0.00	40.83	0.00
.70	1689.58	0.00	102.	641.	0.00	40.83	0.00
1.00	1689.72	.12	103.	918.	2.17	40.83	0.00

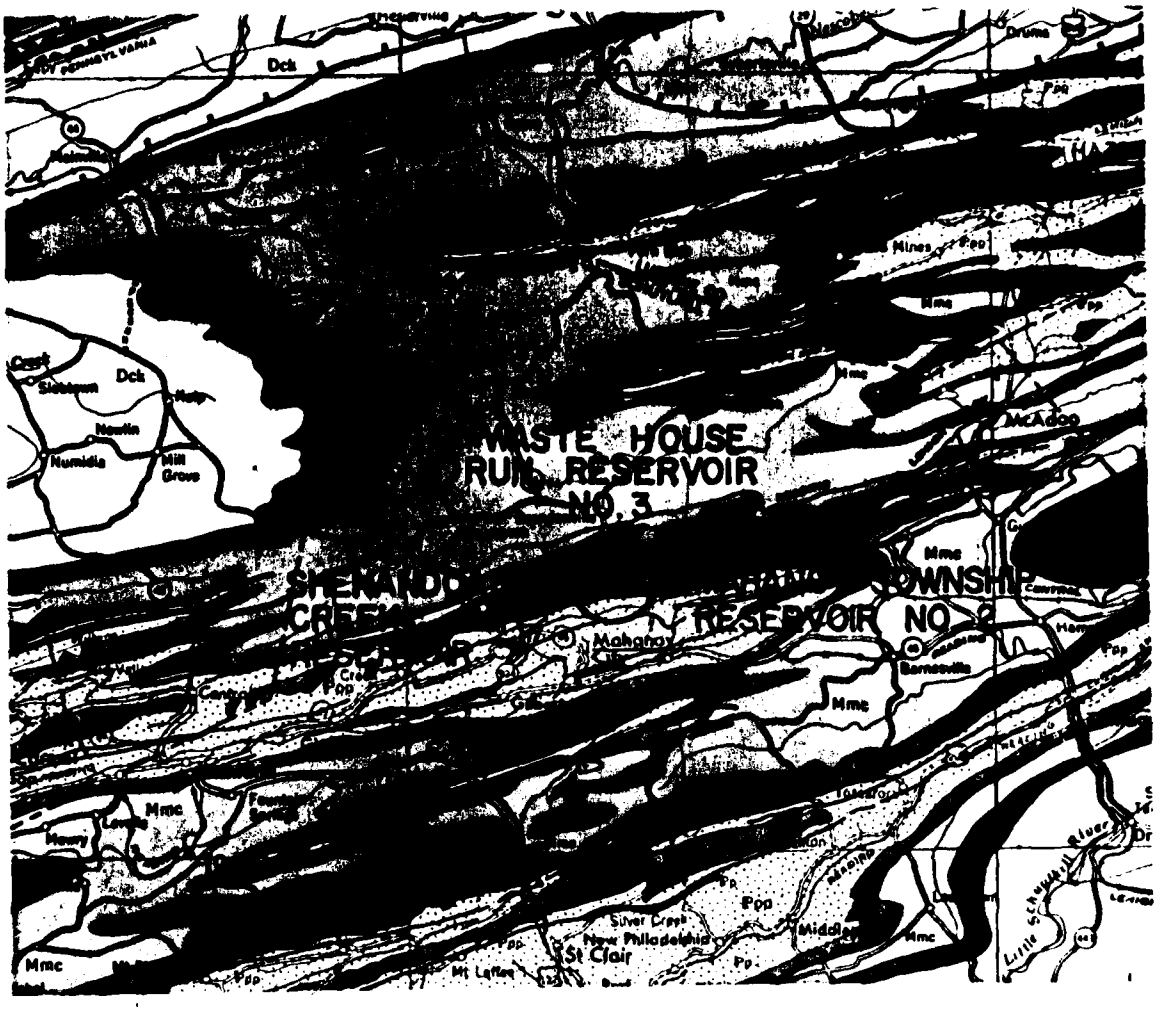
APPENDIX E
DRAWINGS


DRAINAGE AREA BOUNDARY
MAHANOY TOWNSHIP RESERVOIR NO. 2
Paddlers Grave
Waste House Run Reservoirs
Res No 1
Res No 2
Mahanoy Township Reservoirs
Res No 1
Res No 2
Res No 3
Yatesville
MAHANOY
Saint Nicholas
Tailings Pond
N
MAHANOY TOWNSHIP RESERVOIR NO. 2.
DOWN STREAM EXPOSURE MAP
SCALE 1" = 2000'
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
E-1

APPENDIX F
GEOLOGY

General Geology

The Mahanoy Township Dam No. 2 is located in the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. This area is characterized by tightly folded synclines and anticlines. The bedrock underlying the dam and reservoir is the Pennsylvanian-aged Pottsville Group. This formation contains of interbedded sandstone and conglomerate, medium to coarse grained; with some coal and dark shale. The bedding is usually moderately-well developed. Joints are fairly regular, abundant and steeply dipping. The rocks comprising this formation are moderately resistant to weathering and form a good foundation for heavy structures if excavated to sound material. Care should be taken where coal has been mined. Some faulting is evidenced approximately two or three miles southeast and southwest of the reservoir.



GEOLOGIC MAP OF THE AREA AROUND SHENANDOAH CREEK, MAHANOY TOWNSHIP DAM NO. 2 AND WASTE HOUSE RUN NO. 3 RESERVOIRS

Pottsville Group

Light gray to white, coarse grained sandstones and conglomerates with some mineable coal. Includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

Scale 1 : 250,000